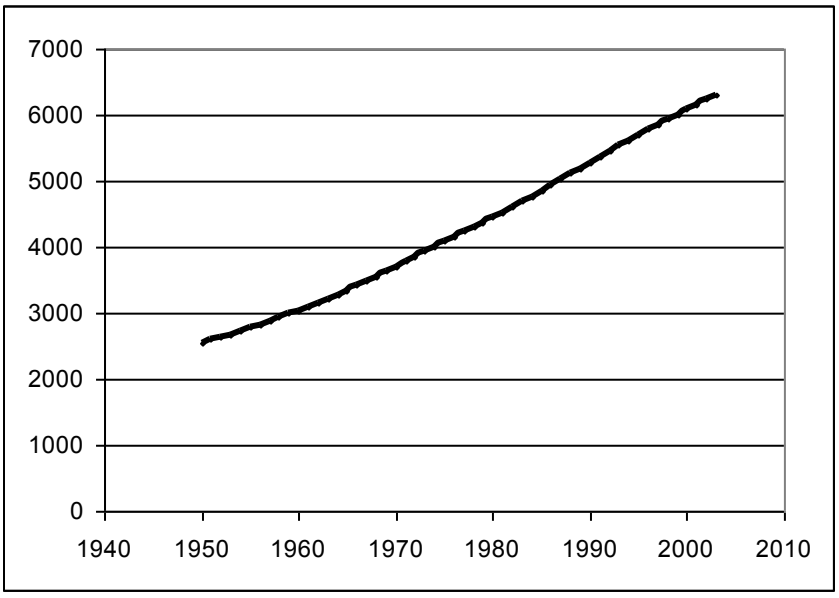
Introduction to Social Macrodynamics. Compact Macromodels of the World System Growth by Andrey Korotayev , Artemy Malkov, and Daria Khaltourina. Moscow: Editorial URSS, 2006. Pp. 10–20.

Chapter 1

Macrotrends of World Population Growth

The world population growth in 1950–2003 had the following shape (see Diagram 1.1[1]):

Diagram 1.1. World Population Growth, 1950–2003 (millions)



Though at first glance world population growth in 1950–2003 looks almost perfectly linear, even a very simple analysis of the dynamics of annual growth rates indicates that the actual situation is far more complex (see Table 1.1 and Diagram 1.2):

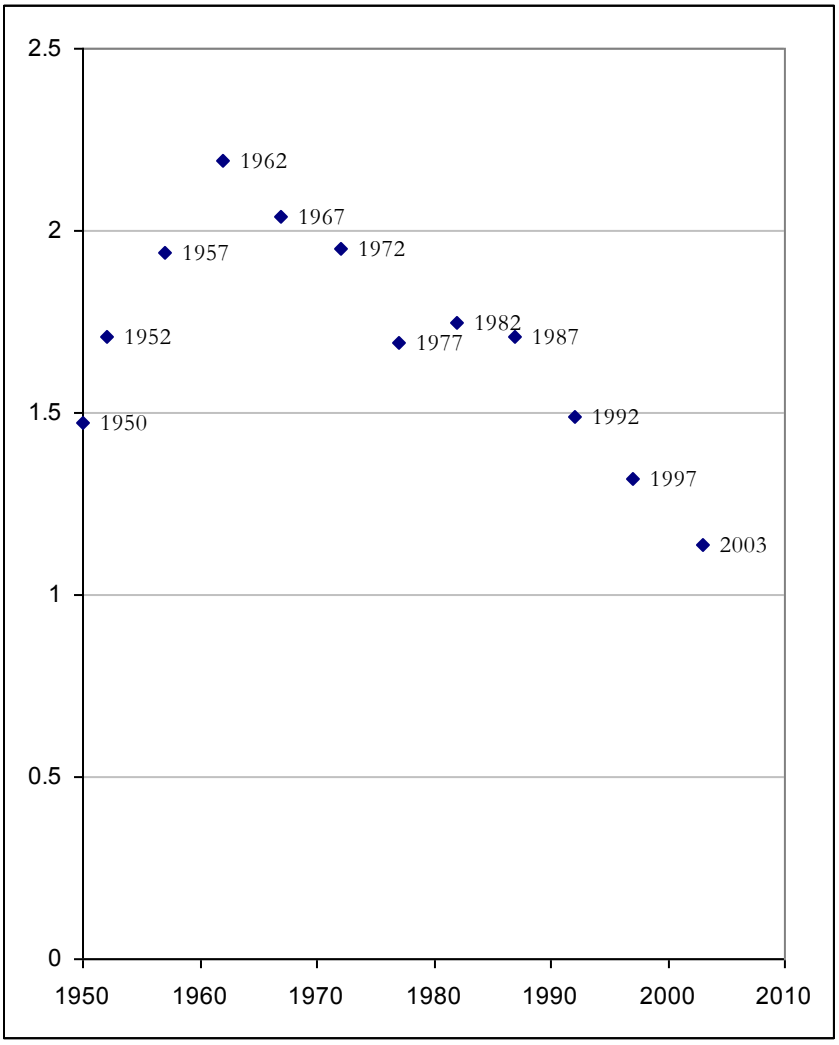
[1] The world population dynamics data for 1950–2003 are here and elsewhere from US Census Bureau database (2004).

Table 1. World Population Dynamics, 1950–2003

Year	Population	Annual growth rate (%)	Annual population change
1950	2,555,360,972	1.47	37,785,986
1951	2,593,146,958	1.61	42,060,389
1952	2,635,207,347	1.71	45,337,232
1953	2,680,544,579	1.77	47,971,823
1954	2,728,516,402	1.87	51,451,629
1955	2,779,968,031	1.89	52,959,308
1956	2,832,927,339	1.95	55,827,050
1957	2,888,754,389	1.94	56,506,563
1958	2,945,260,952	1.76	52,335,100
1959	2,997,596,052	1.39	42,073,278
1960	3,039,669,330	1.33	40,792,172
1961	3,080,461,502	1.80	56,094,590
1962	3,136,556,092	2.19	69,516,194
1963	3,206,072,286	2.19	71,119,813
1964	3,277,192,099	2.08	69,031,982
1965	3,346,224,081	2.08	70,238,858
1966	3,416,462,939	2.02	69,755,364
1967	3,486,218,303	2.04	71,882,406
1968	3,558,100,709	2.08	74,679,905
1969	3,632,780,614	2.05	75,286,491
1970	3,708,067,105	2.07	77,587,001
1971	3,785,654,106	2.01	76,694,660
1972	3,862,348,766	1.95	76,183,283
1973	3,938,532,049	1.90	75,547,218
1974	4,014,079,267	1.81	73,271,828
1975	4,087,351,095	1.74	71,804,569
1976	4,159,155,664	1.72	72,229,696
1977	4,231,385,360	1.69	72,172,075
1978	4,303,557,435	1.73	75,085,858
1979	4,378,643,293	1.72	75,746,226

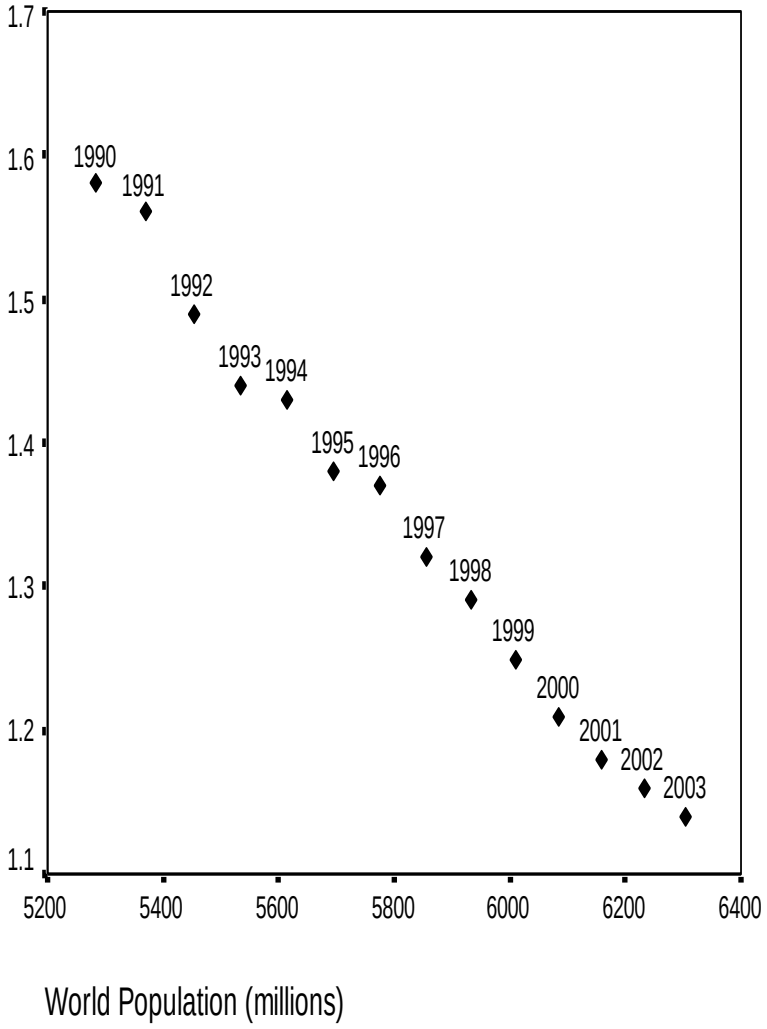
Year	Population	Annual growth rate (%)	Annual population change
1980	4,454,389,519	1.68	75,430,353
1981	4,529,819,872	1.74	79,706,283
1982	4,609,526,155	1.75	81,444,423
1983	4,690,970,578	1.70	80,459,709
1984	4,771,430,287	1.70	81,822,376
1985	4,853,252,663	1.71	83,561,368
1986	4,936,814,031	1.73	86,175,601
1987	5,022,989,632	1.71	86,843,511
1988	5,109,833,143	1.69	86,965,235
1989	5,196,798,378	1.68	87,880,745
1990	5,284,679,123	1.58	84,130,498
1991	5,368,809,621	1.56	84,182,087
1992	5,452,991,708	1.49	81,942,247
1993	5,534,933,955	1.44	80,547,532
1994	5,615,481,487	1.43	80,781,974
1995	5,696,263,461	1.38	79,253,622
1996	5,775,517,083	1.37	79,551,074
1997	5,855,068,157	1.32	78,019,039
1998	5,933,087,196	1.29	76,861,716
1999	6,009,948,912	1.25	75,529,866
2000	6,085,478,778	1.21	74,220,528
2001	6,159,699,306	1.18	73,002,863
2002	6,232,702,169	1.16	72,442,511
2003	6,305,144,680	1.14	72,496,962

Diagram 1.2. Dynamics of Annual World Population Growth, 1950–2003 (%)



As we see, before 1962 one can observe a rather rapid increase of population growth rates. However after 1963 we encounter a clear-cut reverse trend – the annual growth rates tend to decrease rather steadily and fast. In fact in 1990–2003 we observe an extremely strong negative correlation between world population and world population growth rates (see Diagram 1.3):

Diagram 1.3. Correlation between World Population Size and World Population Annual Growth Rate, 1990–2003



Regression analysis of this dataset gives the following results (see Table 1.2):

Table 1.2. Correlation between World Population Size and World Population Annual Growth Rate, 1990–2003 (regression analysis)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	**Std. Error**	**Beta**		
1	**(Constant)**	3.903	0.064		61.290	0.0000000000000003
	World Population (billions)	-0.441	0.011	-0.996	-40.259	0.00000000000004
Dependent Variable: **World Population Annual Growth Rate** (%)						

NOTE: $R = 0.996$, $R^2 = 0.993$.

This, of course, suggests that 99.3% of all the world macrodemographic variation in 1990–2003 is predicted by the following extremely simple equation:

$$r = 3.9 - 0.44N\,, \tag{1.1}$$

where N is the world population in billions, and r is the annual population growth rate (%).

Naturally, this makes it possible to estimate what the future population of the world will be if the recent pattern of relationships between N and r persists, using the following equation (Model 1):

Model 1

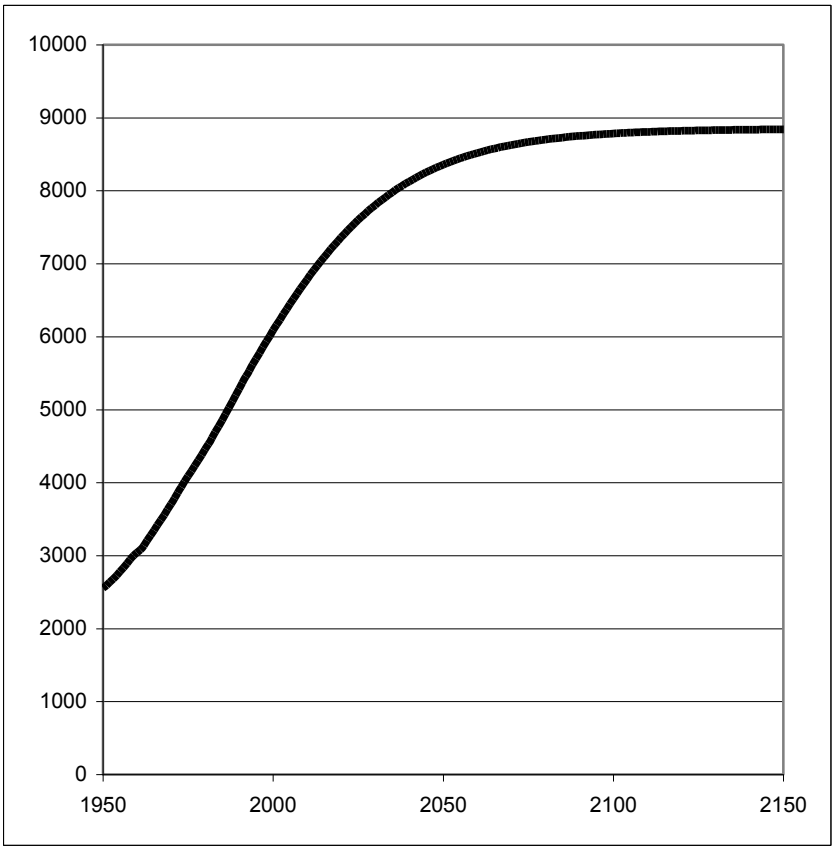
$$N_{i+1} = N_i\,(1 + [3.9 - 0.44N_i]/100)$$

The results of respective simulation starting in 2003 with N = 6,305,144,680 look as follows (see Table 1.3 and Diagram 1.4):

Table 1.3. Future Population (millions) of the World, estimates produced with Model 1 simulation

Year	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*	*2070*
Population	6785.6	7360.3	7801.6	8126.0	8356.8	8517.2	8626.8
Year	*2080*	*2090*	*2100*	*2110*	*2120*	*2130*	*2150*
Population	8700.9	8750.6	8783.8	8805.8	8820.5	8830.2	8840.8

Diagram 4. World Population (millions) in 1950–2003, with Extrapolation of 1990–2003 Dynamic Trend till 2150



How likely is it that actual world population growth will follow this pattern? As we shall see, there are strong theoretical and empirical grounds to maintain that in no way is this entirely unlikely.

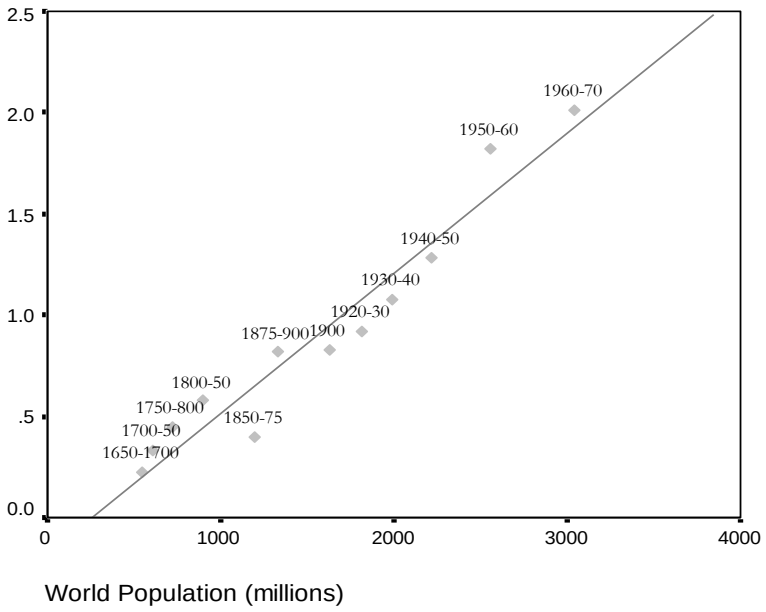
To start with, the pattern of strong linear relationship between world population size and world population growth rate observed for 1990–2003 is in no way unique for the world's demographic history. In fact, just this pattern prevailed for most of human history, at least within the last two millennia (*e.g.*, Kapitza 1992, 1999; Kremer 1993). For example, for 1650–1960 this relationship looks as follows (see Table 1.4 and Diagram 1.5):

Table 1.4. World Population Macrodynamics, 1650–2003

Period	*World Population at the beginning of the Period (millions)*	*Average Annual Growth Rate during the Respective Period (%)*
1650-1700	545.0	0.2253
1700-1750	610.0	0.3316
1750-1800	720.0	0.4463
1800-1850	900.0	0.5754
1850-1875	1200.0	0.3964
1875-1900	1325.0	0.8164
1900-1920	1625.0	0.8306
1920-1930	1813.0	0.9164
1930-1940	1987.0	1.0777
1940-1950	2213.0	1.2832
1950-1960	2555.4	1.8226
1960-1970	3039.7	2.0151

NOTE: estimates by (Kremer 1993: 683).

Diagram 1.5. Correlation between World Population Size and World Population Annual Growth Rate, 1650–1970



Regression analysis of Kremer's dataset for 1650–1970 produces the following results (see Table 1.5):

Table 1.5. Correlation between World Population Size and World Population Annual Growth Rate, 1650–1970 (regression analysis)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
2	(Constant)	-0.172	0.099		-1.744	0.112
	World Population (billions)	0.691	0.057	0.967	12.074	0.0000003
Dependent Variable: **World Population Annual Growth Rate** (%)						

NOTE: $R = 0.967$, $R^2 = 0.936$ (for 1900-1970 $R = 0.981$, $R^2 = 0.962$)

This, of course, suggests that 93.6% of all the world macrodemographic variation in 1650–1970 is predicted by another simple equation (Model 2):

$$r = 0.69N - 0.17,$$

where N is the world population in billions, and r is the annual population growth rate.

On the other hand, 96.2 % of all the world macrodemographic variation in 1900–1970 is predicted by Model 3 arrived at through a similar regression analysis of data for this period:

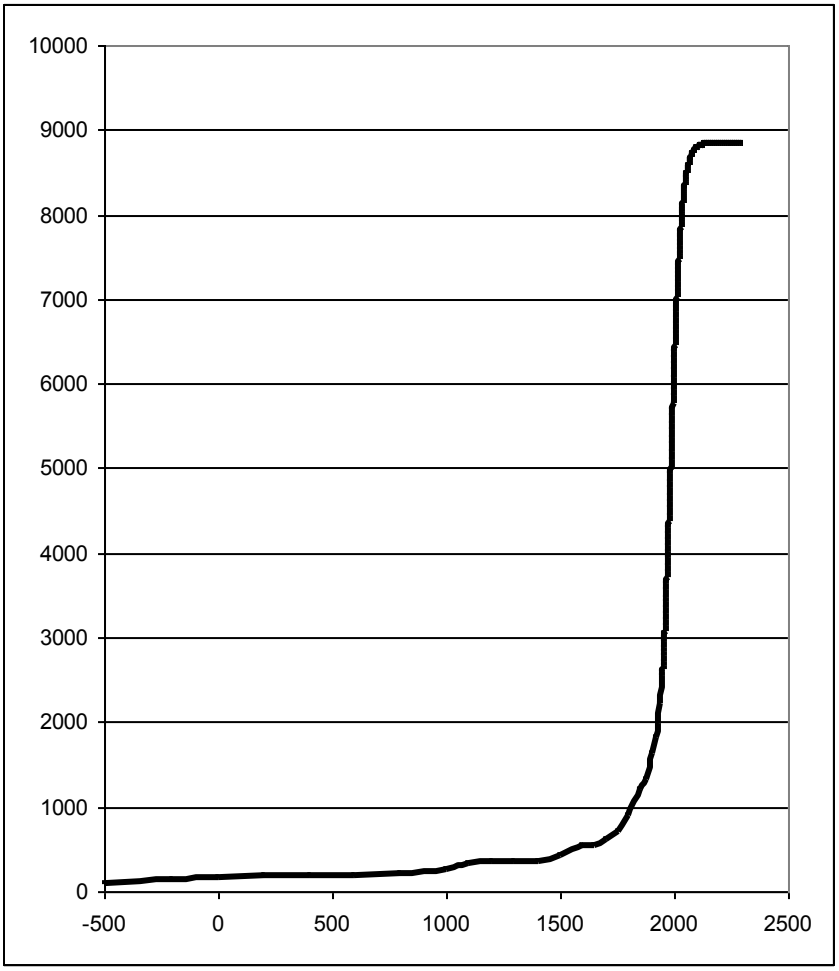
$$r = 0.92N - 0.71 .$$

Thus, very strong and rather uniform linear relationship between world population size and annual growth rate can be observed in historical record for decades and even centuries.

Combining our extrapolation of 1990-2003 world population with the data on world population growth from 500 BCE till 2003 (Kremer 1993; US Bureau of the Census 2004)[2] we arrive at the following picture (see Diagram 1.6):

[2] The other sources consulted are: Thomlinson 1975; Durand 1977; McEvedy and Jones 1978: 342–51; Biraben 1980; Haub 1995: 5; UN Population Division 2004; World Bank 2004.

Diagram 1.6. World Population Growth, 500 BCE – 2300 CE, millions



In fact there is only one really significant difference in the patterns of world population growth observed in 1990–2003, on the one hand, and in the pre-1962/3 era, on the other. In 1990–2003 we observe a very strong NEGATIVE correlation between world population size and annual growth rates. For the pre-1962/3 era we also find a very strong correlation between those two variables. But this correlation is POSITIVE.

Naturally, this means that the long-run world population growth trend in the pre-1962/3 era was HYPERBOLIC. The hyperbolic population growth im-

plies that the absolute population growth is proportional to the square of population (unlike exponential growth when the absolute growth is lineally proportional to population). Thus, with the exponential growth if at the world population level of 100 million the absolute annual growth was 100 thousand people a year, at 1 billion level it will be 1 million people a year (a ten times growth of population leads to an equivalent 10 times increase in the absolute population growth). For hyperbolic growth, if at the world population level of 100 million the absolute annual growth was 100 thousand people a year, at 1 billion level it will be 10 million people a year (the ten times growth of population leads to a 100 times increase in the absolute population growth rate). Note that the relative population growth rate will remain constant with the exponential growth (0.1% in our example), whereas it will be lineally proportional to absolute population level with hyperbolic growth (in our example the population growth by a factor of 10 leads to the increase in the relative annual growth rate 10 times, from 0.1% to 1%). Respectively, the world population growth trend observed in 1990–2003 can be identified as INVERSE HYPERBOLIC (or just logistic).